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REPORT

ON THE

VENTILATION

OF THE

HALL OF REPRESENTATIVES,

AND OF THE

SOUTH WING OF THE CAPITOL

OF THE

UNITED STATES.

TO PROF. JOS. HENRY, COL. T. LINCOLN CASEY, DR. J. S. BILLINGS,
EDW. CLARK, ESQ., F. SCHUMANN, ESQ.,

COMMISSION OF INQUIRY, ETC.

BY

ROBERT BRIGGS, C. E.

PHILADELPHIA.

PRESS OF HENRY B. ASHMEAD,
Nos. 1102 & 1104 Sansom Street.
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REPORT

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VENTILATION OF HALL OF REPRESENTATIVES.

By ROBERT BRIGGS, C.E.

To Prof. Joseph Henry, Col. T. Lincoln Casey, Doctor J. S. Billings, Edward Clark, Esq., F. Schumann, Esq.,

Commission to examine into the Ventilation of the Hall of Representatives.

Gentlemen:—In conformity with your request that I should give you a statement of the system and apparatus for ventilating and warming the Hall of Representatives as originally proposed and constructed, and after personal examination, its present condition and performance, I have to say:

I. Regarding the original plans, that it was proposed to introduce to the Hall, by means of an apparatus for this room only, from the most eligible point about the grounds of the Capitol, the most ample supply of fresh, pure air.

The place selected from which the supply of fresh air was to be taken, was the esplanade or upper terrace at the northwest corner of the south wing of the New Building, between it and the Old Capitol, in the entering angles or recess formed by the connecting building; and from the ground level of this terrace, the air passed directly through regulated windows, into the room in the crypt containing the fan.

The supply of air for the north wing—for the portion of the building occupied by the Senate, was taken from the corresponding point at the south-west corner of that wing, the same arguments as to suitability of place, attach to that choice of position.

This locality was deemed pre-eminently advantageous. The prevailing winds of the District are westerly. It is of the rarest occur-

rence that there is any but a short deviation from this direction; perhaps not one entire day in forty does the wind come from the eastward, or even from due north or south. The western front of the Capitol surmounts an elevation of ground above the level of Pennsylvania Avenue, and of the streets and open grounds beyond those ot the Capitol itself, of perhaps fifty feet height. The esplanade is is nearly level, but is only some thirty feet wide, and is at the top ot a steep terrace rise of thirty to thirty-five feet. The great extent of the Capitol building, (over 700 feet,) from north to south, thus forms a barrier to the westerly currents, which roll upward against it, and effectually prevent the fall of any vitiated air which may escape from the doors, windows or flues. Before this terrace there exists a wide park (800 to 1000 feet in width), carefully graded, and drained, and preserved in the most healthy condition by constant labor and attention, shaded by numerous trees which absorb a portion of the heat of the air, and are still more valuable for the purpose of securing air for the house, in the interception of dust, from the streets beyond the grounds.

The propriety of removal of the point for obtaining supply of pure air, further from the Capitol, and also the condition of air at different elevations as regards purity, was fully considered. The location of any more or less removed point of supply was obviously, from the configuration of the ground, restricted to either west or east of the Capitol, as the marshes then existing north or south (and yet existing to the south) were manifestly unsuitable for sources of pure air, either on the surface or with quite high towers (except some Washington monuments were designed for the purpose). The conditions of westerly winds referred to, would also demand that a point of supply on the east side should be either very far removed or very much elevated, if the emitted air from the Capitol should be certainly dispersed before the supposed mouth for supply of fresh air, were reached. In fact the statement of conditions alone makes it obvious, that of the two locations, the one to the west of the Capitol should be chosen; and the remaining questions must be examined as an accepted basis of a supply of air from this side. Removal from proximity to the building, supposed a tunnel connected to some opening or tower situated on the ground, below the terrace. Twenty years ago, at which time the decision as to source of fresh air supply was made, the Tiber was an open gulley taking the drainage of two square

miles of territory, then but sparsely covered by tenements—the canal was also a broad, stagnant, filthy pool; and the reservations outside the Capitol grounds were pestilent, undrained and ungraded marshes. The carrying of a tunnel down towards these abominations and placing of an opening near, or a little elevated above, the surface of the ground; getting nearer and nearer to the dusty Pennsylvania Avenue; sacrificing all the advantages of distance, and time for removal of dust, would not be approved; and even to-day, with the circumstances so changed in the enumerated conditions at that time, it is doubtful if mouth for entrance of air near the surface would meet commendation. A tower thus becomes the alternative. Its dimension is fixed by the quantity of air needed—40 feet square or 50 feet internal diameter, are the least dimensions requisite to furnish air to both wings and the Old Building together. Its height must be 35 to 40 feet to reach the top of the esplanade alone, and as much higher as might be *conceived* necessary to find the pure air uncontaminated from *all* impurities. How high can this be *conceived?* This becomes the next question involved in the discussion, and it is answered by referring to the results of investigations made before 1855, and frequently repeated since, upon the purity of air in cities at different elevations, the results of which can be briefly stated. There are great variations in the quality of air in different cities, arising from density of population, nature of fuel, character and avocations of the inhabitants; and again from climate, prevailing winds, and winds at the time of observation, hygrometic condition, normal or abnormal, etc., etc.; but after the dispersion of impurity generated in any particular locality, the purest air is generally found from 6 to 40 feet, the most impure at 70 to 90 feet above the level of the ground, with gradation rising to balloon heights. Over any free or open places in a city the dispersion of local impurities is the more completely effected, and the uniformity of condition the more generally obtained; but the elevated air is more impure, when the stratum of diffused chimney exhalation is reached, than it is below.

The Londoner *does not* experience any great sense of purity of air from the top of St. Paul's as a general rule; and the haze of any large city is perceptible for miles on a still day—the entire city is covered as with a blanket by an *ascending* and *dispersing* cloud, and receiving its fresh air from beneath from all sides.

Upon a still day, a tower would manifestly offer little advantage

in its elevation of the point of taking the air, as regards its purity, unless the height were over 100, and perhaps quite 200 feet or more; while on a windy day, in such a locality as that in which the United States Capitol is placed, the average condition of the air at any elevation above the ground would be established.

The objection that the air is heated in traversing the stone surface of the esplanade before entering the fan mouth, can be admitted only in part; for the volume is so great that only the least portion of air comes in contact with the stones, the greater part of it by far, being taken directly from the space; but the same objection attaches with equal or greater force to a masonry tower, which whenever exposed to the sun, will have an upward heated current rolling along and flowing up it, to be sucked in at the top.

A tower or tunnel would have been unsightly; costly in first construction, expensive ever afterwards to draw the air through it, and open to the criticism of scientific men at all times without the possibility of logical support; and although it would have been a *demonstration*, and although it might meet the written authority of many who have considered ventilation, as a problem of what should be done in lieu of how to do it, yet I am satisfied this statement of reasons will show the propriety of the original choice of the place for taking fresh pure air for the ventilation of the Capitol.

The internal dimensions of the room, occupied as the Hall of Representatives, are 139 feet long (east and west); by 93 feet wide (north and south); by 36 feet average height (from general level of lower floor, to the average surface of the under sides of the ceiling); the lower floor, where the seats and desks for the members of the House are placed, is 113 feet long by 67 feet wide, and is surrounded by retiring rooms and private vestibules under the galleries. The retiring rooms (coat rooms) are always open to the floor of the Hall, and receive their ventilation from the Hall apparatus. The gallery walls are about 12 feet high, with a parapet, which makes them show about two feet more in height. The cubical contents of the entire room, with the coat rooms and vestibules, are, very nearly, 500,000 cubic feet.

The South Wing of the United States Capitol is a building 230 feet long (east and west), by 135 feet wide (north and south), outside of the walls of enclosure; (there are extended porches on the east, south and

west sides, and a connecting building on the north side joins the main edifice, or "Old Capitol"); it is three stories in height, above the ground level, and the Hall is in the second and third stories, (the galleries opening from the third floor,) with a basement of dark rooms (intended for depositing stationery in the original allotment of rooms), under the floor of the Hall.

The basement story is 20 feet in floor height, and there is a crypt of perfectly dry, vaulted rooms, beneath the ground floor of the entire building. On the east front of the Capitol, the ground is nearly level (having a slight rising grade eastwardly), and the basement story floor is elevated four or five feet above it. On the southern and western fronts the ground falls off rapidly, giving the esplanade and terrace previously mentioned on the western front.

The quantity of air determined upon was that of 30 cubic feet each minute per individual in the Hall in the coldest weather of winter, and of 60 cubic feet each minute per individual in the Hall, at other seasons, or when desired. The crowded capacity of the floor and galleries (the latter being occupied by seated persons) was estimated at 1600 individuals, and thus the minimum ventilation became 50,000 cubic feet, and the maximum 100,000 cubic feet per minute. [See Appendix A.]

These volumes of air were supplied by means of a large fan, 16 feet in external diameter, which was driven by an independent steam engine of proper dimensions. This fan and its engine are situated in the north-west corner room, of the cellar or crypt of the south wing of the Capitol. The fan was supposed to be required to overcome a total resistance, equivalent to about four-tenths or six-tenths of an inch of a column of water; which corresponds to the pressure of air of two to three pounds upon the square foot: being the total resistance to the passage of the air which should proceed from the air ducts leading to the Hall; from the channels of distribution under the Hall floor; from the mouths of discharge of the registers into the Hall, and finally, from the floors through the Hall, out of the ceiling, and through the roof to the open air. With these resistances the fan was supposed, when running at the rate of 50 to 60 revolutions per minute to give the 50,000 cubic feet of air, and when running at 100 to 120 revolutions per minute to give the 100,000 cubic feet of air, required.

The provisions for heating the air were fully equal to the largest

demand, there being for this purpose, one main coil (in four separated parts) of wrought iron steam pipes, of one inch internal diameter, having a total length of 50,000 running feet (nearly 10 miles) of pipes; which pipes have a total heating surface of 17,000 square feet. The air ducts from the fan to the coil, and from the coil to the Hall, were somewhat tortuous, being necessarily so, to obtain the requisite dimensions without encroachment upon the architectural arrangements of the building; but they have the proper size, and are free from enlargements or angles, so as to afford an unrestricted flow for the air currents within them.

The sources of power, the means of producing steam for the impulse of the air, and for heating it—the boilers—were ample in capacity.

II. The choice of the *system* of ventilation was made by Gen. M. C. Meigs after long and due consideration, and was that known as a *forced* (or plenum) *upward system.*

The work on the Capitol Extension had been placed in the hands of General Meigs in March, 1852, after the commencement of the building, and after the construction had proceeded, to the "completion of the cellars and arches to the basement floor;" and continued in his charge until October or November, 1859, at which time both wings of the buildings were occupied, the Hall of Representatives having been used throughout the session of 1858–9.

Accompanying the first report of General Meigs (May, 1853, to the Secretary of War on the progress of work on the Capitol Extension), are notes of his primary investigations upon acoustics and ventilation, in which he proposed to adopt a forced *downward* ventilation for reasons stated, but subsequent study led to another conclusion.

In June or July of 1855, while General Meigs was pursuing his investigations on the subject of ventilation of the Extension of the Capitol, he became acquainted with the late Mr. Joseph Nason, of New York. Mr. Nason was at that time unquestionably the best informed and most experienced person on Heating and Ventilation in the United States, and his practice had made him acquainted with the requirements of the climate which were not (and as yet are not) properly considered in any publication on the subject. Mr. Nason's eminent skill as a mechanic, his profound information, and his happiness in imparting it, commanded for him the position of a consulting engineer on this specialty beyond any person then or now living. He had been the founder of the system of steam heating by means of wrought iron steam pipes, now so generally employed in all countries; and his investigations and experience in ventilation had led to the adoption by him of mechanical appliances suited to meet the occasion, and which have formed the type of all subsequent

practice. With a highly inventive and appreciative mind, he was a keen observer and student, and his store of knowledge rose to that point, where with all his novelties of application he could not or did not claim the inventors rewards in patents. Yet it is not an exaggeration to say that all the essential details of construction now in common use in steam heating, with the highest refinement of shapes and the closest relation to absolute utility or cost of production, are unimproved and substantially unchanged as they proceeded from Joseph Nason, and beside this, that nine-tenths of the patents of the past thirty years referring either to heating or ventilation apparatus or to any details, are founded upon or trench upon his accepted or discarded practice. Mr. Nason was a pupil (and student) of Jacob Perkins (an American mechanic of world-wide renown) of London, and he faithfully sustained the reputation and aided in the progress of the art of heating which Mr. Perkins established. Mr. Nason was consulted by General Meigs in the preparation of the plans for arrangement of apparatus used at the Capitol Extension.

The following considerations are those which determined the preference for the system adopted:

The comfortable temperature at which the Hall was to be kept was obviously at or near 70° Fah. Now the natural internal warmth of the body is very nearly 100° Fah., regardless of the heat of the surrounding air; and the personal comfort which proceeds from air at 70°, is found to be accompanied by an actual loss of heat from the skin, which is cooled with constancy and regularity and yet without so rapid dispersion of heat as to give the sensation of cold. The breath also is inhaled at whatever temperature of air may subsist at the place, but is exhaled at all times at 90° or 95°. Hence the occupants of a room, the air of which has a normal temperature of 70°, will impart to it such excess of heat as may be given out from the person or breath, and if the temperature is to be kept at the 70° point, some means of absorbing or dispersing this heat must be provided.

[The actual quantity of heat proceeding from the formation of carbonic acid given out with the breath each minute, as deduced from the careful experiments of Doctor Edward Smith, is sufficient to raise the temperature of 30 cubic feet of air from 10° to 7½° each minute, probably about one-third of this heat is taken up in formation of moisture from the lungs and skin.] The exhalations of the breath are composed of air partially deprived of oxygen (that is with excess of nitrogen), carbonic acid and vapor of water with small quantities of organic matter in suspension. This organic matter is recognized to be the source of effluvia and also of disease, and the great purpose of ventilation is its removal. In whatever condition the organic matter escapes from the lungs or exudes from the person and passes off with

the insensible perspiration, it sours or decomposes very quickly—a few minutes only suffice for it to become offensive. It makes the offensive odor which is found so marked in the galleries or *upper* parts of halls of audience, especially in those which are inadequately supplied with fresh air. The exhaled breath has a temperature of 90° (or a little above), but, as it has with it a proportion of six per cent. of carbonic acid, which is heavier than the equivalent volume of air (in which it is diffused and from which it does not separate), the resulting specific gravity of expired air is about four per cent. lighter than that of air at 70°. From these heating effects of the person it follows that any individual is always surrounded and enveloped in an ascending current of air; and this current can be made manifest by experiment and shown to have a perceptible velocity notwithstanding the downward direction of breath from the nostrils. A little spiral of paper mounted upon the end of a knitting needle, or a delicate anemometer (instrument for measuring the velocity of currents of air) will answer to show this phenomena; and the latter instrument will give the ascending velocity over the crown of the head at two to five feet per second.

If this upward tendency of air derived from the contact with the person and the levity of the breath did not exist, it is obvious that no large assembly of people could live for an hour on a calm day. The vitiation of the air by the emanations from the skin and by the exhaled breath with its carbonic acid would bring this about. An army could not form in mass, at a review. M. C. M

If therefore a system of downward ventilation were installed, which should give the least supposable supply of air to each individual in the Hall, the descending current of air distributed over the whole surface of the room would be in opposition to the natural currents produced by the heat of the body. In this way the intermixture of foul with fresh air would be perfectly consummated, and as the volume of air to be introduced (with a least supply) was found to be so much as would affect the entire change of the air in the Hall (supposing the change to occur without mixture) in eight or nine minutes, and the foul air of exhalation must have risen, until by mixture its temperature became that of the room; and it follows that at no time would any person on the floor of the Hall have a single breath of pure air. It is not easy to say how far down in the Hall the fresh air, which is supposed to enter at the top, would reach as fresh air; but it is probable that it would be partly fouled at once, and that the whole nine to ten minutes would be the length of time,

in which the mingling of the exhalations from the person and breath, with the fresh air, would take place; during which time the organic matter in suspension would be partly decomposed. On the other hand, with an upward ventilation the fresh air would be breathed by any person, within half of a minute of its time of entry, with no intermingling of currents, and unmixed with exhaled breath; except by diffusion downward, in opposition to the direction of flow. Besides these considerations of the nature of the air when introduced by downward ventilation, over the head of an audience, it must be noticed in accordance with previous remarks that to preserve the temperature of the room at 70° amongst the audience, the fresh air itself must be somewhat below 70°, and that a downward current will not only meet the natural upward one, but produce a positive flow in the downward direction, which, however small its velocity, *as a cold current*, would be sure to be perceptible, and could not or would not be endured.

There are other and quite as cogent reasons against the introduction of air from above. A prominent one in the Hall of Representatives, if it be supposed that the vitiated air be removed through openings in the floor of the Hall, would be the passage of the vitiated air from the galleries (sometimes crowded with persons) upon the heads, and down amongst the members seated on the floor; or if it be supposed that it be attempted to remove the vitiated air from the galleries, by openings in the gallery floor, there would then be an alarming uncertainty as to the existence of *any* ventilation on the floor below. But without enumerating more reasons, it is enough to claim the sufficiency of those already stated; and to say that an upward, plenum, ventilating system met the views of the writer in 1855, and the adoption and approval of General Meigs at that time. After twenty years more experience, study and examination at home and abroad, and after inspection of the present condition of the ventilation of the Hall of Representatives, the writer is the more convinced of the propriety of the decision then reached.

[It will be noticed that the question of the merits of a plenum or exhaust system of ventilation for the Hall, has not been referred to in these remarks, but further on in this report the defects and unsuitability of an exhaust system either upwards or downwards will be strikingly exhibited.]

III. The Hall of Representatives is a room requiring no *heating.* It is enclosed by corridors, which are at all times and seasons heated to summer temperature, and upon the east and west sides (or ends) these corridors themselves are protected from loss of heat by an external row of well warmed rooms. The basement below the Hall is also warmed, and the iron ceiling above is well protected by a large air space, covered by a copper roof, and although some loss of heat does occur at the ceiling in cold weather, yet the volume of escaping air, which is always a little overheated, is so great that the temperature of the roof space is generally up to 60° or 70° in the daytime, in the coldest weather, rising to 110° when the gas is lighted. The problem is, therefore, how to cool the Hall, and how to deprive the air which it contains, of the heat emanating from the occupants at any given time.

For the occupants themselves the problem is still more embarrassing, for it is how to cool from 500 to 1600 people in the Hall, by means of currents of air cooler than the general temperature of the room, which currents must be introduced and distributed without producing the sensation of cold by any one of the occupants. There is a personal—physical—difficulty involved with the introduction of air amongst a crowd, and consequently near to some if not each of its number, which demands investigation in this place.

The sensation of cold from contact with air is not that proceeding from its temperature alone, but is affected in some means by the hygrometric condition—and to yet greater extent by the action of a current or draft upon the skin. It was stated that in still air [of American hygrometric condition] the comfortable temperature was 70°, but a current of air upon the person at this temperature is uncomfortably cold from the rapid abstraction of heat. At much higher temperatures the sensation of coolness from currents of air is felt. One fans himself when the thermometer stands at 100° with a sensation of relief. This feeling of cold, from air of high temperature, when in motion, proceeds from the rapid removal of the stratum of warm and nearly saturated air in contact with the person and its replacement by fresh air, which is not only cooler but which has not yet become saturated or charged with moisture by contact with a moist surface like that of the skin. In no one of the changes in the three forms of matter—solid, liquid and gaseous—is there so much heat taken up as in the change from a liquid to a gaseous (or vaporous)

form, and in no other body or substance is so much heat absorbed or become latent as in the formation of steam from water, or in other words, in the process of evaporation; and the quantity of heat taken up by the moisture which a dry air abstracts from the skin is so great, that the mere differences of temperature of the air, from that of the skin may almost be neglected in the statement; and it is very nearly correct to assert that the cool sensation from a breeze in summer, proceeds entirely from the evaporation of moisture thereby induced.

Upon this basis it may be noticed that a current of saturated air at 100° would neither remove heat by its contact nor by induced evaporation, and consequently would be incapable of producing a cooling effect, while as the temperature on the dew point should fall, the current would become a pleasant one. With a high temperature and dry air the cooling effect of a current of air (even at 100°) may be very pleasant in the sensation, but will be attended with sun-burning (even without exposure to the sun) and blisters will be produced by the excessive deprivation of moisture from the cuticle or surface of the skin. With 80° of temperature and a high dew point a strong breeze is not unpleasant; nor likely to be injurious after the person shall have acquired some *accustomed* habit of body to endure it; but at 70° and a low dew point, which is the only possible condition of heated air in midwinter, the annoyance of a current of even five feet per second and its unhealthiness are positive facts.

These considerations demand that no decided local currents or counter-currents shall be formed, or induced in any portion of the Hall; and require a distribution of the supply of air upon, or over the entire surface of the floor, so as to produce a uniform and gradual ascent of the current, in all parts of the room. The solution of the problem, then, is only to be reached when we have successfully introduced into the Hall of Representatives 50,000 to 100,000 cubic feet of comparatively cool air each minute, amongst and in proximity to 1600 persons, without its being sensibly felt.

After much deliberation it was concluded to attempt the supply of most of the air for ventilation, from registers, (mouths of entry placed in and about the lower floor of the Hall,) and to permit the galleries to derive their supply, mainly from the ascending columns from the space which they surround. The nearest approach to a uniform distribution, would of course have been attained by the perforated floor and porous carpet of the House of Lords, England; but the habits of

our people in use of tobacco put this method out of the question, and the same objection attached to numerous small open registers, and the best arrangement seemed to be a compromise. The floor of the Hall had platforms or wide steps, upon which the seats of the members are placed, and which are so constructed as to form semi-circles around the Speaker's Desk (the desk being placed in the middle of one side of the Hall) and there were three radial inclined, and two other straight passages or aisles, which led from the highest platform to the forum, Speaker's Desk, in front and at the sides of the floor. The arrangement of the platforms gave to the three nearest the forum a width of four feet nine inches, then a wide one of six feet nine inches, following this two others of four feet nine inches, and from the last semicircle the floor was carried over level to the angles of the room. There were thus seven risers of three inches high each. The aisles began with a step of seven inch rise and thus had a very gradual descent of fourteen inches to the forum; and the construction gave an end or side riser of varying height where each platform joined the aisle.

For the purpose of avoiding the abuses of horizontal gratings or registers, therefore, and yet to preserve the vertical direction of the currents of air, these ends risers to the platform (side risers on the aisles) were availed of, as the places of entrance of fresh air; and as the aisles were but three or four feet in width, the strong horizontal currents from the opposite sides, would encounter and neutralize each other; the intermingled air would have the desired direction upwards, and be so much spread out as a vein of air, as to have a relatively low velocity of ascent. This arrangement gave three main radial sheets of ascending air in the body of the hall, and another main sheet of the same kind along the side upon which the Speaker's desk is placed. Other registers were placed at the base of gallery wall, which were screened by covers opening downward; and to provide an ascending current in the corners, outside the semicircle of the platforms, large floor registers were subsequently inserted in each of them. The coat rooms were provided with ventilating (supply) registers at the foot of the walls; and some flues in the gallery walls connected to openings in the galleries, which were made in the parapet wall in front of the passages to the seats, and delivered a considerable volume of fresh air to them. But much the greater part of the air was made to enter at the floor of the Hall, so that members had the advantage of the first

entry of air into the room. This distribution of the registers provided that in no case was a current of air directed against any person occupying a seat in the Hall, either on the floor or in the galleries.

The fan employed was of a type selected by Gen. Meigs after the published description of M. Combes ("Aerage des Mines"), but more closely resembling a fan made by Jacob Perkins in 1826. It might be called an air turbine. [The proportions of the parts and shapes of blades, etc., were the subject of a paper read before the Institution of Civil Engineers, by the writer of this report, in 1870. More than 100 such fans are used for ventilation of public buildings in the United States at this time.] The diameter of the fan (16 feet) was adopted in order to give a slow and easy motion to the engine, which drove it by direct connection; and its width at the periphery was such as would give at the required pressure, the required volume of air per minute. The superficial area of the width, about the periphery, is 64.34 square feet; but the area of peripheral discharge of air, which is to be taken normal to the 45° angle blades, is 45.49 square feet; whence the least cross section of a frictionless duct to carry away air from this fan, should be 45.49 square feet. The duct leading from the fan, however, had (I believe) an area of 60 to 65 square feet, and this area was preserved until it passed under the Hall floor, where a slight gradual enlargement occurred. The total area of all the mouths of discharge was 80 square feet, but the apertures of the gratings over these mouths, had a total sectional area of not much over 40 square feet. The velocity of the flow of air from the tips of the vanes of the fan when it was giving 50,000 cubic feet per minute, was 1100 feet in the same time (or 19 feet per second); and with 100,000 cubic feet per minute, the velocity was 2200 feet (or 38 feet per second).

It is of course desirable that the current of air in which any person shall be compelled to remain, shall not be much above 2 feet per second, although 5 feet per second is not perceptible when the air is in the summer condition of humidity. The velocity of flow through the apertures in the gratings was very high (*i. e.* 40 feet per second with summer ventilation of 100,000 cubic feet per minute), but within 3 or 4 inches of the apertures, the velocity would fall off 3 or 4 times, by enlargement or spreading out of the stream of air, while the practical result of the opposing currents was to make, at each aisle

a main ascending sheet of 18 inches to 2 feet in thickness, within two feet of the aisle floor.

It must be remarked that comparatively small importance was attached to the procurement of low velocity of emerging air, from the apertures of discharge; but that it was regarded as in the highest degree essential that the resulting currents beyond the apertures, should diffuse into slowly ascending volumes, as nearly as possible, uniformly distributed within the room; and above all so as not to blow upon any one, and thus the entry of air would be made *imperceptible* to the occupants of the Hall.

The spaces of flooring, between the aisles, received their ventilation partly by mixture of counter currents, which did not attain any sensible rate of speed, and partly by diffusion of gases, which does so much to establish the equilibrium of gaseous mixtures in the open atmosphere as well as in enclosed rooms. It was seen at once on the first session, that any one who should enter the Hall somewhat chilled from out of doors in winter, could not acquire warmth in the temperature of 70°, with the desirable celerity, and that more direct radiant heat was necessary. To meet this requirement, fireplaces were made in the coat rooms under the galleries at the earliest convenience.

The entry and distribution of fresh air having been thus provided, the removal of vitiated air was effected as follows: Through the action of the fan, a condition of pressure of air (or plenum) was maintained, by means of which the air would seek to escape by every opening from the Hall outwards; and it will be seen that under such circumstances, any large local outlet would tend to *induce* a current of air within the Hall flowing towards it. This tendency was resisted, and the proper vertical direction and uniformity of upward flow of air in the Hall was insured, by the judicious placing of numerous small outlets in the iron and glass ceiling. The total superficial area of these outlets was assayed to be sufficiently restricted to effect the distributed discharge, and at the same time sufficiently large to give the proper delivery of foul air each instant. The means of egress above the ceiling were mainly two sets of louvres at the ridge or peak of the roof at each end of the building. [These louvres were removed from above the Hall to avoid the possible accident of drifting snow or rain upon the iron or glass ceiling.] But a portion

of the air escaped by leakage through the copper covering of the roof, which is formed of corrugated copper sheets placed overlapping each other; and not soldered, confined or made air-tight at the laps or joints.

The delivery of air at all times was perfectly satisfactory, while the great area of discharge reduced the rate of the outflowing current to a very low one, but when measured by the anemometer the volume of air which passed, was found to correspond fairly with that which was impelled by the fan at any given time. It used to be a matter of exhibition to show that the escaping air was devoid of offensive, almost of noticeable odor, and except when the gas was lighted above the ceiling, was not offensive to breathe.

Ample provision was made to supply *steam* for vaporization or moistening of the air, if a hydrated condition was thought desirable.

IV. Submitting this general account of the origin and nature of the apparatus as it existed in 1858, I will now proceed to state the result of the examination made, at your request, into its present condition and operation, enumerating the changes introduced and the final result on the ventilation of the Hall.

The boilers and running machinery appear now, after eighteen years of service, during which time they have had little repair or restoration, to be in excellent order.

The present engineer reports the boilers to be equal to new ones, but such a statement is of course to be qualified, possibly by referring to *some* new ones. The engine and fan are certainly in good working condition. The main heating coil has suffered from neglect, which occurred some years since. One of the four parts was at some time injured by the freezing of water in the lower tubes (which was an avoidable accident), and it has been removed. With the limited supply of air which it has been feasible to introduce for some years, even previous to the accident, the three parts remaining were, and are of sufficient heating capacity, if the gap made in the bank of pipes by the removal of one part were controlled by shutters, to check the entrance and flow of a current of unheated air beyond the coil. As the main coil now is, the probability of the discharge into the Hall of hot and cold waves is very great. All the regulating shutters originally intended for the distribution of air in entering the large

coil (and indispensable for protection from frost if any part of the main coil should have its steam shut off) have been removed. The remaining parts of the main coil have many split tubes (which probably has been occasioned by frost), and the air now supplied is in some measure, if not entirely, *hydrated* by the leakage of steam and water. On the whole, the heating capacity is superabundant for the present time and season; but restoration to original condition is highly desirable before next winter. The separate pieces of the removed part are in one of the vaults, and a large proportion of their number are available in the restoration, supposing that no new arrangement be eventually considered advisable.

I explored all the air ducts and passages. In company with the present engineer I entered and examined the same—from the inlet of the fan—from the fan to the coil—above the coil to and beneath the Hall floor—creeping in all directions amongst the passages, and finally emerging at the opposite, or southeastern corner of the floor. The present condition of these ducts and passages as regards cleanliness was all that could be asked for; in one or two places there are some piles of bricks and rubbish where some walls have been cut through, but there is no appearance of anything likely to be deleterious.

Near the beginning of the duct, shortly beyond the main coil, there exists the remains of a shallow tank or basin, which was formed by giving a flooring and sides of sheet lead to a portion of the duct itself, at a place where there was an original depression. This is a relic, I am told, of an attempt to *hydrate* or supply moisture to the air by vaporizing water.

It was assumed that the air in passing above and across the basin of water would take up as much as would be needful to give it the summer condition of humidity. This assumption was based upon experience with the scorching currents from an ordinary hot air furnace, which if they do not take up enough moisture to establish the summer condition in a house, are yet very efficient in the evaporation of a proportionately large quantity of water; but in this instance it was found by trial (not experiment or reasoning) that the cool current of air requisite for ventilation of the Hall; when passing with accustomed velocity over the limited surface of water, failed to evaporate the expected quantity, and the arrangement fell into disuse.

In the bottom of this tank there had been an outlet of 2 or 3 inches

diameter, connecting to the drain, which outlet the engineer reported to me as having been found by him unclosed and untrapped. Whenever the ventilation of the Hall ceased, this opening might have become objectionable, and possibly some, not very large, quantity of foul air would escape from it; but at any time when the Hall was occupied and the fan supplying air, the current would be in the opposite direction, and a small quantity of fresh air would *escape* from this hole. Still the existence of such an opening was a decided neglect on the part of a former engineer.

Much change has been made in the passages themselves; originally they were fireproof passages in solid brick-work, nowhere open to the wood-work of the floor, and no gas or water pipes had been allowed to be laid in or even to cross them. [The floor of the Hall was constructed in wood, to prevent the rapid conducting of warmth from the feet, which would have been occasioned by a brick or stone floor.] The changes in the passages, have made many breakages in the side walls and the passages now open in many places, under the wood-work of the floor; greatly increasing the risk in event of a fire, as the burning floor in such case, would then be supplied with air from beneath.

These changes were incident to two several alterations in arrangement of the seats for members. The first of these (made in accordance with the express vote of the House of Representatives) was the substitution of sofas in place of chairs, and the removal of the desks, for each member; which was accomplished in this way: The three radial aisles in front of the Speaker were dispensed with, and the platforms extended over them; the middle portions of the platforms in front of the Speaker was furnished with sofas of the same curvatures, which gave seating room for all the members of the House; and at the two ends of the platform, beyond the sofas, and in the corners of the Hall, were placed large tables, with chairs, for use of those who had occasion to write, or to use papers or documents. This arrangement discarded the aisle ventilation, and to replace it and yet retain the upward distributed currents of air, a great many small circular registers were placed in the floor of the platforms in front of the sofas. Much care was taken in the construction of these registers. They were so made that nothing could pass through and lodge in the air passages, while the tops were free to be lifted, for removal of anything dropped into the basin.

It was found that tobacco dried immediately, by the current of air passing through the registers, and emitted neither dust nor effluvia; both of which are so offensive from a saturated carpet. Alterations in the air-passages under the floor were made at this time to conform to the new position of registers; but their fire-proof character was preserved in the change. Although the grouping of the registers did not present apparently quite as equal a distribution of entering air as the aisle arrangement, yet the ventilation of the Hall (as I am informed) continued to be satisfactory.

This disposition of sofas and tables proved, after three or four months' trial, so objectionable to the members, that the House voted for an immediate restoration of the desks and seats, taking a recess during the session for the purpose; and the second change gave the third, and present arrangement of the desks, seats and floor, together with the present method of supplying air to the House. This change removed the small registers and relinquished the upward direction of the currents of entering air; and the air is now supposed to enter mainly at the risers or fronts of the steps of the semi-circular platforms. There are now seven semi-circular platforms, narrower than before, of four feet four inches width; which have seven front risers, each of four inches height; and upon these risers there exists a continuous band of two inches wide, of small apertures; each two inches high by one inch wide, and placed one inch apart. These apertures are in front of a continuous air-passage under the floor, and are controled by numerous registers, so as to be regulated independently for every one foot or eighteen inches of length of the riser. The air of course emerges as a thin horizontal sheet* from the upper risers and is

* The adhesion of a current of air to a surface, whether horizontal or otherwise, is one of the properties of fluids, liquid or gaseous. If a stream of water be directed against a plate it will spread over the same, rolling along, augmenting in width from diminution of velocity arising from the fluid friction; the fluid friction presenting a resistance in the direction of the impulse; the stream or sheet will also increase in width by assuming another direction of flow; but the current will not leave the plate until some relation of the force of gravity, or other force, is established with the derived impulse of the stream, at the place of separation.

The tenacity of a current of air to the floor or a wall is remarkable. Sir John Leslie, sixty years ago, uses this physical law as an explanation of the changes of barometer following the *tangential direction* of impelled and induced wind currents. A strong wind existing upon the surface of the earth will not leave it, but merely spread the thickness of its stratum, each particle endeavoring to preserve its uniform velocity and the retardation of volume becoming evident in reduction of barometrical height.

directed over the face of the platform below them; traversing the platform, the sheet receives an augmentation in thickness from the next layer of air which escapes from the next risers, and so on until the whole seven platforms are swept over; forming a broad sheet of air directed against the back of the legs of those who occupy seats upon the platform.

When it is recognized that the whole area of these outlets at the risers is such, that with the proper quantity of air supply, it must pass them with a velocity of 20 to 40 feet per second, and at the distance of one foot in front of the risers, where the stratum of air may be supposed to become four inches (the whole height of the riser) in thickness, not less than 5 to 10 feet per second; and also that the air *must* be cool, so cool as to feel cold to the naked hand: then it becomes apparent that this ventilation cannot be very comfortable. After these strata shall have accumulated and converged as a great horizontal current within the circle of the forum, they must of course be transformed into one ascending column, in front of, and about the Speaker's desk. Two large circular floor registers, possibly 3 feet in diameter, discharging upwards, which were inserted in the upper corners of the floor when the first change was made, have been retained to the present time. These yield a very large part of the air now entering the Hall, as the riser registers are frequently closed off.

The sensation of cold from the horizontal air currents, was by no means an imaginary one—the complaints became general; and after one season of endurance, during which the experiment of stopping the fan was essayed, with the result of want of air for breathing (as at present); with the alternating operation of heating the air until it felt comfortably warm (95° to 100°)—when the heat of the hall became unbearable. After many trials in the alternate ways, it was concluded that the defect was in the *heating* apparatus; and that the cool air which was so obnoxious, was air that had lost its heat in the passages under the floor. A subsidiary heating apparatus was therefore devised, and placed under the floor of the hall; where is now to be found, in some places in the fire-proof work and in others, under the wooden flooring, a number of groups of cast iron steam radiators (or heaters), together with all the requisite wrought iron steam and return water-pipes; which subsidiary apparatus was intended to warm the air for ventilation so that it should not feel cold! Of course the new radiators would answer to heat the air (or at least a portion of what

should have been introduced in cold weather), and if the frosted part (one-fourth) of the great coil had at the time when the new system was introduced, been then injured or removed; in such case the radiators would be available in some measure: but even with these suppositions the provisions for controlling the heat were so imperfect, that the result in merely warming of air was sure to be unsatisfactory. Yet this apparatus must have had considerable use, and must have produced some local highly heated currents; as there is evidence, in quantities of resin which has roasted from unprotected joists and boards of the flooring, that a high heat and small volumes of fresh air, have at times co-existed near the radiators. The combination of this secondary heating apparatus with the first one, and the complication of pipes and appliances of control, must be a great puzzle to each one of the successive engineers into whose hands the heating and ventilating of the hall has fallen; without experience, precedent or instruction. In the course of these changes and additions there has been placed in the air-passages several lines of pipes connected with the heating, besides many other pipes for gas or water supply; but except that it is manifestly improper to make such use of the passages, and likely to impair the working of the apparatus as a whole, if it had been operated according to its original plan, and that there is always a strong probability that out of sight passages in *common use* will become places for collection of rubbish (which abuse has *not* followed), it cannot be said that any detrimental results have happened from these causes. The impairment of the efficiency of the apparatus, by the changes and openings from the passages, is so considerable, that the other misuses can be passed by without comment.

In the original construction it was supposed that the pressure of air from the fan (less some *regulated* but very small difference of not over one-sixth the total pressure which would be expended in supplying the air at the further extremity of the hall), would be kept up *behind* the openings of emergence, and would form the motive power to affect the entrance of the air against the resistances of the apertures of the mouths, and all other resistances to the flow of air, until it finally was expelled (vitiated in but a slight degree, from its abundance) at the roof. All passages leading to the point of entry were ample, with, as before stated, easy curves and smooth sides. The existing condition of the air passages, will be appreciated by example of one of the branch entrances which I measured: a line

of the semi-circular riser openings having, by rough approximation, a little under one and a half square feet of *total* area of apertures (in openings of two square inches each), has now an entrance, from one of the main aisle ducts, of a half a foot area. This entrance leads at right angles from the aisle duct, into a narrow, very rough brick-work channel of four or five inches width, by possibly two feet in height. Of course the pressure of air or velocity of discharge from this vein is wholly inadequate to supply the quantity desired—still it is amply large until the horizontal currents are abolished.

V. After investigating the present modes of introducing fresh air, the next step in examination, was into the means provided for escape of foul air. The original system has already been described, and the effect of the present arrangement for introduction of air at the risers of the platforms, in producing a large ascending column of air in the vicinity of the Speaker's chair, has also been stated. This ascending column, with even a limited quantity of air supply to the Hall, became a vertical upward current of very high velocity (but, like any other ascending current, scarcely perceptible to those within it), which, on reaching the ceiling, would spread out as a sheet in search of the openings for escape. A portion of the air would pass out, but the effect of the horizontal currents of entry on the floor was not only to form a blast of their own volume, to concentrate at the Speaker's chair, but also to *induce* the air above them to take the same horizontal direction, and the supply of air for this induced current would be furnished or sucked from the upper part of the room, whereby a general circulation of the atmosphere in the Hall, would become established in a continuous roll, accompanied by descending currents of perceptible, but not very high velocity along the northern gallery and wall. As the iron ceiling of the Hall, when the outer temperature is below (say) 50°, is cooler than the air within the Hall, the sheet of air in passing across it became cooled, and the current of descending *cooled* air which fell upon the heads of the members was objectionable at most times; but in cold weather, and on any day when the sun did not warm up the air space over the ceiling (at night the gas gave all the heat needful, besides accelerating the discharge of air), the downward drafts became insupportable. [See Appendix B.]

The existence of these currents was attributed *to the effect of the*

wind upon the roof, supposed to have been deflected by the Dome on the Centre Building, which had been erected about the time of the change in the method of introducing the air on the floor; and upon the ground of this attributed cause it was decided to make the roof above the ceiling so tight, that no wind could enter at it, and to remove the foul air positively by means of suction fans. The old system of air discharges at the roof was now dispensed with. The openings in the walls of the Hall which led to the chambers under the discharge louvres, were shut up by close doors; and a plaster lining was formed beneath the copper roof, so that it should no longer be porous; and, as the walls which surround the Hall itself are carried up solid to the roof (which covers Hall, surrounding corridors and rooms beyond them in common); there was formed a comparatively air-tight chamber between the ceiling and the roof above it. On the north side of this chamber (under the roof) there was a passage way which led over to the roof space above the connecting building between the old Capitol and the South Wing. In each of the four corners of this connecting building there existed a flue or shaft, whose original purpose, for two of them, was for chimnies for the boilers, while the other two were used for gas and water pipe mains, but were nearly vacant places. Some changes of pipes, and by dispensing with the use of one of the chimney shafts (turning all the boiler flues to one chimney only), rendered two of these shafts available, one for the downcast to the cellar, where some fans could be placed, and the other for the upcast of foul air above the roof. Two suction fans of six or eight feet in diameter, with a suitable engine, were placed in the cellar of the connecting building, and completed the *apparatus* for evacuation of foul air from above the ceiling of the Hall.

The cross area of either one of the foul air shafts, is about 27 square feet (if the lining of chimney has been removed); which opening now represents the point of restriction of the ventilation of the Hall. When the length of the shafts is considered, the area is evidently insufficient for the ventilation of 100,000 cubic feet of air per minute.

But the want of dimensions is by no means the chief defect. It has been seen that with present arrangements for entry of air, the actual supply has some limit in the endurance of the members exposed to drafts; and from the result of a trial by one of the associates in this Commission, I am informed that only 15,000 cubic feet of air per

minute was furnished to the Hall through a given point in the main duct beyond the fan of supply, while a contemporaneous observation at the suction shafts, gave the volume of air *extracted*, to have been 25,000 cubic feet of air per minute. From whence was this surplus of 10,000 cubic feet of air per minute derived? Obviously it must have leaked in at the doors of the Hall or Galleries. And this fresh source of new air in the Hall demands an inquiry into the condition of the air which has been thus taken from the corridors.

I will not attempt to give minutiæ of the ventilation and appliances for maintaining pure air in that portion of the South Wing outside of, and surrounding the Hall itself; but simply will assert that there exists, ready for instant use, every facility for the purpose; and that scarcely a tradition of its manipulation or working, has come down to the persons at present in charge of the apparatus. The regular and adequate supply of pure air to rooms and hall-ways is now more neglected than even that for the Hall, and the action of the suction fans in borrowing 10,000 cubic feet of air per minute was merely an act of removal into, or exhausting through the Hall; a volume of vitiated air—not only what had been impaired by breath, but also the product of gas burning, together with that which came from the restaurant and cabinets, all of which exhalations, gases, odors and impurities should properly be *expelled* from the very spot where they have originated at once, through the proper discharge ventilating flues, which are to be found in every room and place in the building; and by no means be allowed to contaminate the air of the Hall.

This defect of the exhausting system, as exhibited in this case, whether in combination with the plenum one or alone by itself, can be pronounced radical. No care of manipulation will ever so apportion the supply of fresh air that an exhaust fan can be relied upon to remove that vitiated in the Hall alone, except by at all times driving the plenum fan at such speed as will render the labor of exhaust fan unnecessary (always provided that the exhaust fans are not employed in sucking air to the cellar, and forcing it to escape from the same, through very restricted passages).

The Committee Rooms' fan and its air ducts are in working condition. I was assured that some mould had been permitted to accumulate in them, but this was, or is, only an evidence of almost complete

disuse; for with the fan supplying but half its air, they would be kept as dry as a gale of wind could dry them. The controlling air valves, for regulating and securing proportionate delivery of air in all parts of the building, whether near to, or distant from the fan, are displaced, and no one possesses the knowledge of how to rearrange them. The heating coils are out of order, and the means of regulating the heat has been forgotten—even the fact that it is necessary to adjust the heat has faded from all recollection. Still, although some restoration of apparatus before next season will be desirable, yet the introduction of an abundant ventilation could be effected *at once*, by merely putting into use the dormant means at hand.

It should be admitted, however, when speaking of the exhaust apparatus, that one marked and apparently good effect came from the suction of air from the Hall. By its agency the great descending sheet of air, which before fell upon the gallery and floor, on the side in front of the Speaker's chair, was partly intercepted and drawn out by the overhead suction duct, above the gallery ceiling on that side; and the great ascending column was probably no longer a vertical one, —the colder currents from the ceiling, were the first to be abstracted from the room, so that the *semblance* of relief from the cold wind, which was imagined to come from "over the dome of the Capitol and enter the roof," was in some degree a reality to the feelings of those who had suffered before from cold drafts upon their heads.

VI. It is easy to see how the ventilating and heating apparatus of the South Wing and Hall of Representatives has come to its present condition.

Since the work was planned and built, many changes of superintendence have ensued; each new direction brought men to operate it to whom the apparatus was novel and strange; few parallel apparatus exist; in no other nation or land, except in America, do halls of audience, crowded with people, demand ventilation against similar diversities of climate, for sessions of six to twenty-four, or even forty-eight, hours of continuous occupation.

Those who have been brought to take each new control, have in no case been principals or even assistants in the management of apparatus of like character. With this ignorance, which required learning from the very ground not only how to use, but the time and pur-

pose of use of his apparatus; each new engineer or doorkeeper not only could *not* count upon instruction from his predecessor, but he has possibly been often, intentionally misled.

I can assert positively that the engineers as a class and individually, must have been generally competent in their business and following as steam engineers and as mechanics. This fact is apparent from the condition of the boilers, engines and machinery; for after eighteen years' work, with very little substitution or change, all is in good running order. Beyond the engineers' department, the defects and depreciations are the results, rather of want of information than of neglect. As before stated, the very knowledge of the functions which parts were to subserve has passed away; even the numbers of the rooms ventilated by certain ducts and heated by certain coils, have been painted out; and no record remains in the hands of the director of ventilation, so that the figures on the doors of the coil chambers in the cellar are unavailable as information. Neither the intelligence nor the intentions of any of the successive engineers is brought in question by these observations.

The relation of the engineer to the ventilating apparatus, is much the same as that of the engineer of a factory, to the spinning and weaving department. There may be men of competent knowledge and skill, who would direct the latter, while attending to the boiler and engine; but the practice of manufacturing is *not* to entrust such dissimilar duties to one individual.

VII. There was left in the office of the Capitol Extension, and probably still is to be found in the hands of the architect, complete plans, embracing every detail of the apparatus. [The voluminous character of these plans, especially of detail, and their difference from architectural construction, would necessarily tend to make them incomprehensible without a key from the original designers.] The abrupt departure of Gen. Meigs, and the complete absorption of the control of the apparatus into the hands of others, have necessarily prevented the architect from acquiring much knowledge of the system or mode of operation, especially as the responsibility for result did not in any way rest upon him; and any interference or assumption of authority would almost certainly have been resented.

It cannot be claimed that the original apparatus was perfect in design, or beyond improvement or amendment, but it can be averred

that, with judicious employment of the appliances furnished; it *was* possible to introduce that given quantity of fresh air, which is the requisite for healthy ventilation, amongst the throng of people in the Hall, and into the several committee rooms and corridors, with the least occasion for complaint from drafts.

Since the completion of the apparatus, during the past eighteen years, the writer is not aware that any startling or essential improvement in the system, or its parts have been devised or applied. The most valuable modification in detail has been the one for controlling the temperature of the air by admixture of heated and natural currents, by registers which cannot be closed off, but only tempered to suit the requirement for heat in the room. This was first used at the Capitol Extension in conjunction with the last coil put in in 1858; but has been generally adopted for all buildings heated by currents of air, where the plan of the building has been suitably arranged with flues from the foundation. The arrangement presents no advantage except that it relieves the engineer of a charge and responsibility, to control the heat of the entering air, to such degree that the occupant of a room will at all times *desire* the register for supply of air to be wide open [a charge long since forgotten at the South Wing of the Capitol].

More recently (within two years past) statements of the attainment of large success in ventilating halls of audience in England, under the patent of Mr. Martin Tobin, have been published in many engineering and scientific journals. An examination of Mr. Tobin's patent shows that he claims broadly the introduction of air in a vertical direction and permitting the ventilation to occur solely by diffusion.* The methods adopted appear to be numerous standing inlet pipes, five feet or so in height, placed all over a room, which discharge freely upward.—The result is stated to be eminently satisfactory.—The method is substantially, that first employed in the Hall, only that the pipes were avoided in our case. Mr. Tobin's practice must be quite unsightly, and would not meet favor except as a last resort in the Hall of Representatives.

* There was a previous arrangement for distribution of air around the room, by means of a continuous opening at the top of a high (5 or 6 feet) wainscot; whereby a current of air was introduced imperceptibly into a crowded court, the substitution of fresh air, in the middle of the room, being supposed to occur by diffusion.

This example was referred to, at the time of planning the ventilation of the Hall.

VIII. The success of the most perfect ventilating apparatus lies in the manipulation. Many defects may be covered by intelligent direction and watchful care; but no perfection of system or detail will overcome ignorance or negligence on the part of the operators.

The *measure* of success of a ventilating apparatus is found in an absence of thought of its very existence, by those subject to its influence. This standard of excellence was at one time attained and supported, and for the first two or three years of occupation of the building no comment or remark as to the ventilation was made; and the result of any endeavor to elicit opinions from members, generally led to an assertion that they knew nothing about it, and could give no opinion on its merits. This condition of mind on the part of the members should be restored.

The course to be recommended by the commission should have full consideration, and I could not, from my two visits of a few hours each, undertake to suggest any instant or radical action.

The arrangement of the desks and seats for members must be accepted as fixed, and there must be a new disposition of registers to meet it.

If it shall be decided that the whole volume of air cannot be introduced in imperceptible currents amongst the members, or that the presence of numerous registers will be open to serious objections, it may well be considered as to how to introduce air for the Galleries independently. I must state that this alternative was considered by Gen. Meigs 20 years since; but the fascinating idea of introduction of *all*, or most all, the fresh air amongst the members was the ground for deciding against an independent ventilation for the Galleries. It will, however, be found that the arrangement of air ducts under the Coat Rooms was planned with a view to dividing the stream of air between the Floor and Galleries, and that there exists over the Coat Rooms a space suited to hold distributing air pipes of the desired sizes.

This two-fold system would possess an advantage in the winter season. Those who occupy the Floor need and require a drawing-room heat, while the occupants of the Galleries are clothed with heavy garments; and their dresses are really uncomfortable when the temperature rises above 65°, and oppressive at 7-° to 75°; which latter temperature is as low as the Galleries can now be kept with a temperature of 70°, below on the Floor.

I will not pursue these considerations further. They are subjects

for deliberation rather than of report at this time. The past and present of the apparatus are facts which I have stated as briefly as I could; the future requires discussion, and the conclusion I cannot anticipate. [See Appendix C.]

This paper which I now present to the Commission has been examined by Gen. Meigs, and while it is to be accepted as my own individual opinions and views, yet I am able to say that he confirms the facts and statements, as substantially agreeing to his recollections of them

APPENDIXES.

APPENDIX A.*

THE QUANTITY OF AIR SUPPLY TO THE HALL—ACTION OF FAN AND CONSIDERATION OF PASSAGES.

I have not been able to find amongst the notes in my possession, any record of experiments, as to velocity of currents of air produced, or of the quantities of air delivered at any time, by the fan for the Hall of Representatives. There must be some record of these amongst the papers in the office of the Capitol Extension, if they now exist, as my recollection extends to several especial observations by deputies, as well as by myself. There was imported by the Capitol Extension, a Neumann Anemometer (such as is described in Peclet, "Traité de Chaleur"), and another much less sensitive was made by Würdemann. Both of these instruments were re-adjusted, and their constants ascertained, by placing them in motion in a still room, on the end of an arm of fifteen feet radius, which was swung at constant speed of rotation about an axis; and they were further tested, by as careful comparative observations with each other, and with a water column pressure gauge in currents of wind, as we could make. The "King" pressure gauge, which multiplies the height of column of water pressure, by giving motion to a delicately balanced hand on a dial plate by a cord, which passes over a small barrel on the axis of the hand, from the float, was not known in 1858–9; but one of these, which was made under my instructions without knowledge of King's contrivance, was sent to Washington in 1862; when its use corroborated within practical limits, the correctness of the original water column observations; and also showed a reasonable correspondence of indication of pressure, when opposed to currents of air in the main ducts, with the velocities as given by the anemometer.

The anemometer observations were at all times taken in the duct near the fan, either at the entrance of the air to the mouth, or behind the fan, at some point where the duct was well defined in shape; repeated observations in different places in the surface of cross section, were selected with a view to obtain the mean rate of flow at that sec-

* See page 7.

tion; the anemometer being attached to a light staff which permitted the observer to be removed from obstructing the section. There were concurrent observations taken at times in the Hall by the anemometer; but the rapid, almost instantaneous, diffusion of the emerging currents (excepting always when they are upon, or along some surface, to which they can adhere), vitiated all attempts to estimate quantities in this way, and the experiments were only useful in exhibiting effects at certain distances from the openings.

The phenomena of the flow of air through a pierced grating can be readily understood. If we suppose a grating of one inch square openings and of four-tenths of an inch wide bars, so as to be one half space and one half solid, and of considerable extent of surface, it will be seen that a current of air will, within a very close distance, probably two-tenths of an inch (one half the width of a bar) lose half its velocity and become a uniform one: were the bars as wide as the openings, so that the total surface of openings would be one-fourth that of the entire grating, on this supposition of one inch square openings; at a half inch from the surface, the current would be uniform, and have but one-fourth the velocity of emergence. With the bars any other width, the same rule will hold good until some extreme limit of distance is reached. Openings two feet apart, regularly spread, on the floor of the Hall, would unquestionably verge into one great ascending current within a foot from the floor.

As the ducts were of brickwork, without connections or breaks leading to any other channels, and without possibility of leakage; it was certain that any volume of air which passed a given point in them, must enter and go through the Hall; for the purpose of ascertaining the volume supplied to the Hall, therefore, it was deemed sufficient to rely upon measurements taken at the entrance from the fan. Some experiments made with the Senate Fan, at different seasons of the year, of which I find notes amongst my papers, will answer to show the performance of the House Fan as originally operated. The Senate Fan is only 14 feet in diameter, while that of the House is 16 feet, but the former is 1·4 feet wide at the tips while the latter is 1·28 feet. The difference of dimension arose from the restricted area of the ducts for the Hall, which demanded extra pressure to supply them, and consequently the Hall Fan was made 16 feet in diameter, in this way securing a desired

speed for the engine, with a higher velocity for the tips of the blades. As the volume of air emitted by the fan would have increased beyond the requirement for the air ducts if the width of the tips (at the periphery) had been augmented in proportion to the diameter, a reduced dimension was adopted, so that not only the same pressures, but also nearly the same volume of air will proceed from either the 14 feet or the 16 feet fans when run with the same linear velocity of tips of blades; while with the same *angular* velocities the pressures will vary as the square, and the volumes in simple proportion, of the diameter.

The following is extracted from rough notes in my possession :

TABLE.

Senate Fan—14 Feet in Diameter by 1·4 Feet Width at Periphery.

Date of Experiment.	Numb. of Rev. per minute.	Pressure at the Fan, in. of water col.*	Temperature External Air.	Velocity of Air in the Ducts.†	Volume of Air furnished to the Chamber per min.
June 7, 1858...	80	5-16th	....	....	40.052 to 44.764‡
June 14, 1858...	80	5-16th	67°	1241	48.400
June 14, 1858...	100	7-16th	"	1596	62.240
Jan'y 10, 1859...	50	3-16th	....	....	41.116§

* Referred to the air in the engine-room, which corresponded to the external air, very nearly, the intermediate pressure between inlet and outlet side of Fan was uniformly double these figures.

† The area of duct at point of observation was 39 square feet.

‡ This was apparently a continued observation of some hours, during which the Fan was kept at 80 revolutions per minute.

§ Some careful observations of velocity of ingress of air at the several mouths of entry into the Chamber made concurrently with the duct observation accounted for about 33,000 cubic feet of air as entering at the time—the deficiency of 8,000 feet was, of course, what was diffused beyond the surfaces of estimate. The large quantity of air moved for the small rate of speed of the Fan and small apparent pressure can be attributed to the ascensive power of the column of warm air in the building, as it was cold at the time.—My record does not give external temperature.

The tabular results of these trials with the Fan for supply of air to the Senate Chamber, were in accordance with others made with that for the Hall, as well as with those for the Committee Rooms, at the same time; and using these by comparison as data, I can assert the former supply of air to the Hall, to have been from 50,000 to 100,000 cubic feet of air per minute, as required. The indications of total pressure, at the Senate Fan, was from 3-16ths to 7-16ths of an

3

inch; and as a large part of the air for the Chamber was supplied in the galleries (the floor having too limited an area to furnish it), the length of ducts, their crookedness and obstructions were quite as great as those of the Hall; from which it can be inferred that it was not an improbable assumption, that six-tenths of an inch pressure from the Hall Fan would certainly give impulse to, and supply the allotted quantity of 100,000 cubic feet.

The flow of currents of air through a plate, when they emerge from a chamber where the air is at rest, follows the same laws as the flow of liquids, and the orifice is taken as subject to a co-efficient of contraction of area (= 0·7 about) in applying the general formula (corrections for expansion, etc., being neglected), $\frac{v^2}{2g} = h_1 - h_2$.

To transform $h_1 - h_2$ of air into pounds per square-foot, it is only necessary to divide by the number of cubic feet of air to the pound, at some assumed or stated temperature, [13·25 cubic feet at 70° Fah. (barometer 30″)—which is near enough as the limits of practical accuracy in this case], and this can be further reduced to water column pressure in inches by dividing by 5·2 lbs.—or the weight of an inch deep of water on a square foot (at 52° Fah).

This formula applies to *orifices of all sizes*, within large limits of dimension, as the ratio of contraction due to the internal flow of liquids, (coming from the consideration of least resistance to particle movement) is the same for openings of all sizes, when the plate is supposed to have infinite extension. But it does not apply to the emission of air from *apertures*, as they are to be seen in the Hall, for in these the air comes to the apertures with full velocity (in place of being quiescent air under pressure); and while the air must encounter some resistance of contraction of vein, the co-efficient of contraction is altogether modified, becoming zero if the mouth of the aperture is merely the termination of a channel or pipe. It can only be said that the *total* pressure must represent the flow through the most restricted openings—all the duct or passage frictions—all the fan frictions—and, in addition to this—must be summed the pressure of plenum in the Hall. It would be feasible to obtain a series of pressure indications at any point in the air passages, which would, or could, be made to indicate the relative speed of the fan below, and also the quantity of air it was moving; but it could only be done by comparison of observations, and adapted to the given locality for indication; and the ex-

hibition of the performances would not follow any simple relation of pressure to volume, as the volume changed.

Much thought was wasted in the attempt to devise a set of instruments of indication and communication; with the final conclusion that the instruments would either become so elaborate as to be incomprehensible, or if simple would possess the value of the fair—cloudy—storm—of the barometer; the temperate—summer-heat—blood-heat—of the thermometer; or the rain—fine—of the hygrometer. The advantages of mechanically directed or performed manipulations, are the certainty of repetitions of accomplishment, but unfortunately this is dependent upon some uniformity of condition, which must be anticipated. And, again, the establishment of a healthy atmostphere in the Hall of Representatives is so intermingled with the preservation of the comfort of the individual members, that no rules will ever render the climate of Washington amenable to meet the contingencies; and the adoption of standards, which do not admit of great latitude in discretion, by those in charge of the ventilation, will inevitably, lead to contention and disagreement.

It was concluded that intelligence and watchfulness were essentials both for the officials of the Hall, and for those of the Engineer Department—and accord between them must be maintained.

APPENDIX B.*

HEAT OF THE ROOF SPACE OVER CEILING, AND ITS EFFECTS UPON CURRENTS IN THE HALL.

The loss of heat, by the air in the roof space over the ceiling at times during the day in cold weather, must have been very great; and unless the ventilation were actively kept up, so as to ensure an upward, outward flow in all the interstices of the iron ceiling, a current of cold air following down the under side of the sheet covering of the roof, to the eaves, or walls enclosing the Hall, and then spreading over a part of the iron ceiling, with a strong tendency to escape downwards, into the Hall itself, might and would be found.

Nearly 18,000 square feet of surface of sheet glass and copper (allowing for the corrugation) have an intermediate temperature

* See page 23.

between the internal and external air; when, if we suppose the internal temperature to be 70° and the external to be zero, the surface of the roof would become 35°, and in case of a high wind, which would abstract heat much more rapidly than the gentle currents of the interior, even 30° or 25° may have been reached; but the abstraction of heat from the internal air would bring *its* temperature below 70°, and a consequent fall of that of the envelope would ensue, so that finally, for excessive estimate, the surface of cooling may be assumed at not over 25°. This assumption will give the cooling effect of each square foot of roof, upon the three cubic feet of air (to the foot of surface, supposed for coldest weather ventilation of 50,000 cubic feet, which leaves the Hall per minute at 70°), as that which can be computed to reduce the air from 70° to 50° (very nearly); and the computation exhibits an apparent probability in its amount. If, combined with this refrigeration of the expelled air, a small amount of leakage of very cold air at the joints of the copper roof sheets is presumed, a still lower temperature would exist at the sides of the roof space, so that the entering of a cold current into the Hall could only be prevented by a uniform and perfectly distributed pressure of air outwards at all the apertures of efflux. [The lighting of gas above the ceiling would at once increase the temperature of the space, above that of the Hall below. At the season of the year, and at the time of day when the coldest weather is likely to happen, the gas will generally be lighted. This may be the reason why cold currents in the Hall, were not noticeable for the first three or four years.]

When the change of method of introducing of air on the Floor both restricted and prevented the entrance of the proper quantity of air, the refrigeration of the roof space would be carried to a yet lower temperature, whilst the opposing out-flowing current would lose their strength; and as the new arrangement *provided* a roll of air, the tendency of the cold air to fall into the Hall, would be not only unopposed but be induced.

The plastering of the inside of the copper roof was, under the circumstances, a very proper and justifiable proceeding, and I am not prepared to say but that it might have been the proper thing to do regardless of any other changes in the method of ventilation.

This explanation is, I think, enough to account for the cold air which was supposed to have fallen from over the Dome. [Still there may be a real current at times from that cause, but if there is—a fact

which can be detected by trial with smoke on windy days—should it be found that downward drafts do exist from this or any other cause—the remedy will be some low mouths or towers of discharge, of large superficial areas (not less than 100 square feet for the two), shielded by cowls, so made as to take advantage of winds from any direction in ensuring the delivery of foul air—always trusting to the plenum for controlling it.]

The same line of argument which has been followed here in showing the effect of air on the external roof surface, at low temperature, with, however, an opposite result upon ventilation of the Hall, can be applied to the effect of air at high temperature, and also to the effect of the heat from the rays of the sun (the latter, of course, being much the more important agent of the two). Whenever the covering of the roof is at higher temperature than that of the roof space over the ceiling, a sheet or film of heated air will follow up the under side of the sheets, and *tend* to escape at the peak; and if the air needed for this purpose, is freely supplied from the Hall below, there will be little addition to the heat of the roof space, as air will not mingle downwards, and is of itself an almost perfect non-conductor of heat. The removal of foul air from the Hall, with much uniformity, will be accelerated by the action of heat.

There is another question involved with the temperature of the roof space at times, which does not admit of so ready solution as that of the abstraction of heat from the roof surface by external influences. The lighting of the Hall by gas burners above the roof calls for a large combustion of gas. About 5500 cubic feet of gas each hour is burned whenever the Hall is lighted; calling for 1900 cubic feet of air per minute for combustion only, and generating heat enough each minute, to raise the temperature of 50,000 cubic feet of air, from 70° to over 125°, (if no loss of heat at the roof or ceiling occurs.) The temperature of the gases of combustion, allowing a double volume of air for dilution, and supposing one-half the heat to be radiant, or emitted from a flame of gas light, is very great (1300° Fah.), while the absolute temperature of the flame is certainly above 5200°; and the radiation of heat from these lights is very perceptible, even to those who occupy seats 30 feet below; and especially noticeable in summer, when the increment of heat, above (say 85° or 90°), becomes oppressive. No means of alleviating this effect of radiant heat, or of reducing the quantity of heat which accompanies a given quantity of gas burning,

when the gas is of given quality, has yet been found. But the great object of my calling attention to the gas burning at all, is to have kept in mind, that whatever scheme of ventilation of the Hall may be essayed, the provision of air for the gas burning, and the ventilation of the roof space must be fully considered.

Common coal gas has the following constituents per hundred parts: Hydrogen, H_2, 44 to 48; marsh gas, CH_4, 34 to 38; olefiant gas, C_2H_4, and other hydro carbons, etc., 6 to 8; carbonic oxide, CO, 5 to 7; carbonic acid, CO_2, 1 to 3; air, N_2O, 1 to 3; aqueous vapor, H_2O, (saturation at 40° to 60°,) 1 to 2. The specific gravity of coal gas is about 0·430, which makes the volume of a pound of gas at 70° equal to 31·4 cubic feet (neglecting fractions, too small to be of consequence in this estimate) = 0·0318 lbs. per cubic foot, Taking an average of the constituents of coal gas, they can be reduced to 53 parts of hydrogen, 34 parts of carbon and 6 parts of carbonic oxide, which are combustible; leaving 5 parts of non-combustible substances. From these data, the heat given out by *complete* combustion can be calculated—hydrogen gas will evolve in its chemical change to vapor of water (including the latent heat of the vapor) 62,000 units of heat, while carbon is becoming carbonic acid, evolves 14,500 units, and carbonic oxide, in changing to the same form, evolves 4,400 units—with the following results:

COMBUSTION OF 100 POUNDS OF COAL GAS.

Combustibles.		Oxygen required.	Air required to supply oxygen.	Air required to effect complete combustion.	Units of heat per lb. of combustible.		Units of heat, total evolved.	Product.
H_2O	54	432	1,944	3,888	62,000	=	3,348,000	H_2O = 486
C	35	93	420	840	14,500	=	507,500	CO_2 = 142
CO	6	8	36	72	4,400	=	26,400	
Totals,	95	533	2,400	4,800			3,881,900	628
Deduct latent heat of 486 lbs. vapor @ 1000°,							486,000	
Total units of heat from 100 lbs. coal gas (95 combustible + 5 of non-combustible)......................							3,395,900	

Of this quantity, of 34,000 units of heat per pound of coal gas, it does not seem to be an improper assumption, that one-half will be dispersed as radiant heat, and the other will be communicated to the gases of combustion, and deseminated by convection and intermixture with the surrounding air. The limited base from which the flame of a gas burner emerges, as compared to the magnitude of the flame or burning surface, prevents the loss or expenditure of radiant heat upon the fuel (which again imparts its heat to air in contact before burning), and thus reduces the convected heat to its least quantity. This leaves the convected heat from one pound of coal gas, as equal to 17,000 units; and preserving the assumption, of the accompaniment of the air for combustion by one volume of air in addition, it will be found by computation based on the specific heats of, vapor of water = 0·475, carbonic acid = 0·217, nitrogen = 0·245, and air = 0·238; that the specific heat of the melange equals 0·263, and the temperature of the gases of combustion (49 pounds), arising from the absorption of 17,000 units, will be 1,300°.

Again if we suppose a burner of 4½ cubic feet of gas per hour, which is equal to 0·00239 pounds of gas each *minute*, we find the dispersion of 40·05 units of heat by

convection; and the same quantity of heat by radiation, in the same minute's time. At this rate, the 1,228 burners over the ceiling of the Hall of Representatives, will consume 5,526 cubic feet of gas per hour, and give out 49,181 units of heat each *minute* by convection. If the quantity of air passing away from the Hall is accepted at 50,000 cubic feet, also per minute, its weight (at 70°) is 3,700 pounds, and with the specific heat of 0·238, there will proceed 880 units of heat for each single degree of elevation of temperature; whence, in dissipating the 17,000 heat units, an increment of 56° will attend the intermixture of the gases of combustion with the vitiated air; bringing the temperature of the foul air escaping from the roof space to 126°; or higher, if the air from the Hall is above 70°.

The radiant heat emitted from the burner would be expended upon the surrounding objects, which will either absorb or transmit it (in part); and the absorbed heat will be finally dissipated by convection to currents of air in contact with the bodies of absorption. A portion of the radiant heat will be transmitted through the glass (about 40 per cent. of what is emitted against it), to the room below, where it will be necessary to cool the air of ventilation correspondingly; but the most of the radiant heat will be imparted to the metal, and other surfaces of the roof space; where it would seem that eventually the heat would accumulate, until nearly the whole quantity of heat produced by the gas burning, radiant and otherwise, would have to be taken up. This would call for an increment of temperature of about 110°; giving 180° as the temperature of the foul air emerging from the roof.

In point of fact, it must be said, that the highest heat recollected by the writer, as having been observed in the roof space at any time, was only 115°—but that temperature is high enough to make the means for controlling the flow of foul air from gas burners the subject for serious consideration.

It may be well to give, as a final comprehensive statement, the fact that the 1,228 burners of 4½ cubic feet of gas per hour, will burn 5,526 cubic feet of gas in this time, or 176 pounds of gas; and each pound of gas will produce about 3½ times as much heat, as is given from the burning of a pound of coal, upon an ordinary boiler grate. From this it appears that the heat produced above the ceiling of the Hall by the gas lighting, is that which would be generated by the burning of 600 lbs. of coal per hour on a grate of about 50 to 60 square feet of surface.

This question of gas burning, makes it proper that I should eall attention to a disuse of one of the regulating provisions for supply of gas, which disuse, has been very injurious in its effects on the ventilation. There was originally in the line of main gas pipes, in the plaee now occupied by the suetion fans, a gas governor, which controlled the flow of gas so as to preserve a uniform pressure in the building and to prevent inerease of pressure, either when the great Hall system was extinguished as a whole, or when any change of pressure was made at the gas works, in foreing the supply of the city. This governor may be yet in existence, but out of order; but it was in working eondition for six or eight years. In 1866 (I think) it was found, by the writer, to the eomplete surprise of all the persons then employed at the Capitol, and it was then discovered to have controlled

automatically for eight years—unrecollected and untouched, in constant motion every day and almost every hour of the day—the admission of gas to the building, so that a *blow* or flare of gas had been an unknown occurrence.

At the present time the broken and smoked shades, the free discharge of gas where a burner had blown out, and the consequent smell of gas which pervades the building and is sucked into the Hall, are the consequences of the neglect or removal of this valuable regulator.

APPENDIX C.*

IMMEDIATE MEASURES TO BE TAKEN TO IMPROVE THE VENTILATION OF THE HALL.

The measures to be recommended for the procurement of immediate relief are first, and above all, the restoration of the method of introduction of air into the Hall with positive upward direction, and with general distribution of the mouths of discharge. The riser openings must be closed altogether, or else their entire length must be shielded by a deflecting shield which shall remove the tendency to establish the great converging, horizontal, floor current, now so offensive, when any considerable volume of air is supplied. A shield of wood or metal—the same height as the step, four inches—placed two inches in front of the present riser, would merely advance the edge of the steps (with the thickness of the shield), two and a half or three inches, and could be made so as not to be noticeable as a novelty or makeshift; and the total superfices of these openings for admission would then be 144 square feet, so that if half the air needed for maximum ventilation passed through these openings, the velocity of efflux at them would be about ten feet per second; which current at one foot elevation would not exceed two foot per second, and at the height where it could come into bodily contact with any one sitting in a chair near by, not over one foot per second. The registers behind the present apertures in the risers would answer to control the distribution. Having in this way made it feasible to supply air in the Hall; the conduction of air beneath the floor to these lines of entry should be made certain, by some enlargements and roundings off of the passages, so that there

* See page 30.

should be no restrictions of area, or angles, to prevent the adequate flow along them. It may be well to insert two more large registers, in each of the triangular corners formed by the semicircle of the platform and the angles of the room; and these registers, together with the ones now in these triangles should have *air-tight* brick ducts of supply, leading from the main air passages, with proper curves to prevent eddies and loss of momentum of the current.

All openings from the air passages to the flooring should be at once closed and the passages made once more suitable for the conduction of the air to definitive points. This course is rendered imperative (if for no other necessity) for the purpose of getting the proper quantity of air at the further (or eastern) end of the Hall; the introduction of air being at the western end. It will be found, by examination of the building, that the large marble corridor in the basement, has an iron ceiling which comes up close under the Hall above; and the plans of the air passages will show that on, or across, the line of the aisle in front of the speaker, the requisite sectional area was obtained only by using the channels formed in the iron box architraves of the lower corridor.

Consequently the main air passages from the fan to this point *must be intact*, or else the leakage or escape of air from uncontrolled outlets will so far relieve the pressure, as to affect the supply on the eastern end, and be especially disastrous upon that supply, when the volume of air introduced at a given time is not large. The adjustment of the equality of supply of air at the two ends of the Hall, under these circumstances, was provided for by registers placed below the floor in the sides of the air passages; which registers regulated the quantity entering the flues leading to the gratings in the Hall; and as these flues were disproportionately large they became in fact chambers of equilibrium, in which the air existed at that definitive excess of pressure which would overcome the exit through the grating at a constant velocity, regardless of the differences of pressure in the main passages.

The registers were at first adjusted with great care by the ballistic effect of the emerging currents on paper pendulums of uniform size and weight of load, so that the velocity of efflux for 60,000 feet per minute was practically equal at all points of the Hall. At this time no regulation of the distribution remains. * * * *

The Suction Fans can be dispensed with, with the greatest advantage, as soon as suitable openings can be made in the roof for the egress of air. I have not the areas of the original louvre openings at hand, but my

recollection leads me to the opinion that they were not so large, as to relieve the roof chamber of such pressure, as would ensure the outflow of air at the joints of the corrugated copper. The plastering on the inside of the roof now prevents any escape of air in this way, and the openings should be made large enough to admit a nearly free discharge of the spent air. Under no practical condition can the down-take and up-cast shafts be made to pass the quantity of air which should go through the Hall in summer, because of want of area. The velocity of passage of this air pre-supposes such relative pressure that at any time when the supply fan does not furnish enough air, the abstraction of air from the rest of the building is inevitable. There is no necessity of the air in the roof space being further treated than *permitted* to escape.

No mechanical objection can be made to the suction fans for the Hall. In fact they are in principle, and in construction of parts acting upon the air, essentially similar to those for supply of air. The chief and apparent differences arises from the entrance of air at both sides of the suction fans, while it is taken in to the large supply fan from one side only; and in the use of iron cases in lieu of a brick chamber for the fans to run in; but the suction fans are small in effective section, and a higher velocity of current and greater expenditure of power is demanded to pass the same volume of air.

The apparatus for the ventilation of the Committee Rooms, outside of the Hall, should be *instantly* put into performance of its work. This alone will help the whole ventilation beyond expression. The specific operations for this purpose would involve, if each point was discussed and set forth intelligently to the Commission, quite as much writing as is given in this report in the Hall alone; I will only say, therefore, that the apparatus exists comparatively in good order and unchanged, so that direction is nearly all that is requisite.

The Restaurant has grown from a place to lunch, to the magnitude of a hotel; and the ventilating flues from the crypt, where the cooking is done, have been appropriated as a chimney, for an extra fire (I think that was done as long ago as 1860), and no means of taking away the odors of cooking now exist. These odors are not very offensive to hungry people when fresh, but they are the accompaniment of organic matter which is probably in combination with vapor of water, and the latter (with its organic matter), is absorbed by any hygroscopic substance near it. The organic matter does not decom-

pose rapidly, but is retained in its place of absorption for a long time, gradually changing and emitting a characteristic fœtid smell which becomes permanent in the walls of unventilated kitchens. The kitchen and the rooms of the crypt near it, can now be mildly stigmatized as vile; and the odor permeates beyond, into the basement rooms above, and is sucked into the Hall. It would be very easy to connect a large flue from the top of the arched ceilings of the kitchen to the upcast foul air shaft, and remove the vapor of the cooking—of course it may be needful to provide air supplies to the kitchen to prevent the ventilating flue from overpowering the chimnies—but in some way this nuisance should be corrected.

The cabinets and water closets in the basement are also open to grave complaint. They have proper and adequate flues for the escape of air. No entering flues lead to them. It was intended that they should derive their fresh air from the corridors and vestibules, which were supposed to be supplied by air under pressure seeking to escape, so that the currents would always set into the doorways. The infrequent and partial working of Committee Room Fan, and the relinquishment of the ventilation, has allowed the air to stagnate in these cabinets until they have become offensive, and their odor at some distance beyond the places themselves is perceptible.

The remedy here is that suggested before.—Put the ventilating apparatus to work at its best effect.

APPENDIX D.

THE FULL CONSIDERATION OF THE SUBJECT OF VENTILATION AND WARMING.

This report has been restricted to the consideration of the subject of warming and ventilation in two ways: first, no general discussion has been attempted; and second, even the application of principles or methods to the Hall ventilation has been limited to those with regard to which, it seemed to the writer that some doubt existed either in the minds of the Commission, or of other persons who have examined into the subject with insufficient knowledge of the physical or structural conditions.

Thus no comment has been made upon the quantity of air requisite. It has been assumed that the volumes of fresh air proposed to be sup-

plied per individual and per minute would meet the approbation of the Commission, and no facts or arguments on this point were deemed necessary. To any one who desires to study primary questions, a simple reference to a standard authority; Dr. Edmund A. Parkes' "Practical Hygiene," 1866, will be more instructive than a brief treatise of recapitulation of his data on these pages.

Dr. Parkes' treatise on the nature of air, its several impurities from all causes, their removal or dilution into excessive volumes of purer air, is exceedingly thorough and ample; yet he does not give proper weight to the effect of difference of humid condition—a change which makes our Washington temperature of comfort 10° higher than that accepted by him, while the midwinter temperature of comfort in Montreal is 20° higher at least—and he fails to consider in any way the methods of supply of the designated quantities.

To live comfortably every man in the United States should *have* an income of $600 per year, is much like the assertion, that 50 to 60 cubic feet of air should be supplied to each individual in a room each minute.

Dr. Morrill Wyman's "Treatise on Ventilation," 1846, contains some practical details as applied to American climate. Other works, the best of them German or French, are filled with constructive details applicable to our own use. E. Peclet, "Traité de la Chaleur," 1860–3, being the most extensive and thorough in all regards; but the practice of the mechanism is always likely to be precedent to the record, and in ventilation and heating, what is undescribed, is by no means an unimportant part of what is known; while the American practice, of Joseph Nason, is almost entirely unpublished.

The respective merits of the different *systems* (as they are improperly called) of ventilation has not been discussed in my report with anything like the fullness, with which they would be presented in a general treatise on the subject. Any examination into the nature or directions of currents, or of the process of diffusion which accompanies upward or downward, horizontal or vertical, influx or efflux, or even much allusion to them in words has been avoided; and my inquiries and statements, have been confined to the consideration of the especial example of the Hall of Representatives. It must not, therefore, be assumed, that while I have asserted that an ascending current is the sole possible course compatible to the conditions in the Hall, that under other conditions other proceedings in ventilation, may not only be possible, but may also be advisable. Thus it must be recognized

that where occupied rooms, in which the cubical space per inhabitant is relatively large (600 to 1200 cubic feet) to that of a hall of audience (300 cubic feet, accompanied by much disproportion of height in the Hall of Representatives) are *heated* as well as ventilated by currents of air at low temperatures, the only way to secure the desirable warmth on the floor, is to abstract the colder air which has chilled on the windows or walls, from or near the floor itself. And this statement applies, to either the method of heating by currents of warm air entering the room by flues (leading from heating surfaces placed in the lower stories) or to the heating by direct radiating surfaces (so called) in the rooms themselves, where the fresh air is derived either by leaks at the cracks of doors or windows, or more rarely, by openings for admission specially provided near the heating surfaces.

Those who have had experience in the warming of storehouses, offices or workshops (or even of habitable rooms) by low pressure steam, or by hot water at low temperature; and have attained a competent knowledge of the requirements to give the temperature of comfort (the procurement of which sensation having been all that was deemed essential by most people); are apt to carry their information beyond the conditions of their own practice, and to assume that the same methods and appliances which gave satisfactory results in their experience will prove equally successful in all other cases, including, of course, halls of audience of all kinds, amongst which the Hall of Representatives can be classed only as a case of special qualifications.

The questions of cooling of air in summer, of production of a warmer condition in winter, together with the numerous applications of medical, physical or mechanical laws involved, are out of place in this paper. They might require consideration if it were undertaken to answer or reply to the numerous propositions which have been made in reports offered for the consideration of previous committees of Congress; but, with the conviction that the Commission desire only to be told how, and for what reason, it was proposed to supply an abundance of fresh air at the several seasons—warmed to the temperature of comfort in winter, and in quantity to the volume of comfort (as near as possible to out of doors in the shade) in summer; I have not followed the proposition to change the seasons into a perpetual spring time.

The truth is, all our heating and ventilating appliances are a compromise of conditions—a truth extending beyond all mechanical operations to the phenomena of nature itself.

ERRATUM.

REPORT ON THE VENTILATION OF THE HALL OF REPRESENTATIVES,

U. S. CAPITOL, WASHINGTON,

TO PROF. JOS. HENRY, COL. T. LINCOLN CASEY, DR. J. S. BILLINGS, EDW. CLARK, ESQ., F. SCHUMANN, ESQ.,

COMMISSION OF INQUIRY, ETC.

By ROBERT BRIGGS, C. E.

Substitute for pages 37, 38, 39 and 40, Appendix B. the new pages sent with this.

This correction of the note on the heating power of gas involves no changes in the body of the text except on page 37, line 27. for 1900 read 1124, and same page, line 42, for 5200° read 4760°, which are now corrected in the proper places.

ROBT. BRIGGS, C. E.

220 South 4th St.,
PHILADELPHIA, Nov. 28, 1877.

Please remove pages 37, 38, 39 and 40 of the pamphlet sent you in 1876. and insert the above.